

A BIOLOGICAL ASSESSMENT OF SITES IN
THE RUBY RIVER WATERSHED:
MADISON COUNTY, MONTANA

Project TMDL-M04

July and September 2002

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A report to

The Montana Department of Environmental Quality
Helena, Montana

by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in July and September 2002 from 19 sites in the Ruby River Watershed, Madison County, Montana. Sites in this study lie within the Montana Valley and Foothill Prairies (MVFP) ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in July and September 2002 by Montana DEQ personnel. Sample designations and site locations are indicated in Table 1. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1. Sample designations and locations. Sites are listed in upstream-to-downstream order relative to the Ruby River, and within specific tributary watersheds. Ruby River Watershed, July and September 2002.

Site ID	Station ID	Activity ID	Location Description	Sample date (2002)	Latitude	Longitude
SHOV01	M04SHOV01	02-U344-M	Shovel Creek 150 ft upstream from mouth of Ruby	9/18	44 - 50 - 38	111 - 59 - 43
COAL02	M04COALC02	02-U346-M	Coal Creek	9/19	44 - 49 - 36	111 - 58 - 43
COAL01	M04COALC01	02-U320-M	Coal Creek u/s from bridge on FS road 100	7/11	44 - 51 - 00	111 - 59 - 56
HWKE01	M04HWKEC01	02-U345-M	Hawkeye Creek near mouth of Ruby River	9/18	44 - 52 - 11	112 - 00 - 02
RURWF01	M04RURWF01	02-U354-M	Ruby River - West Fork about .5 mile above mouth (Ruby R)	9/26	44 - 54 - 24	112 - 00 - 23
WRMS01	M04WRMSC01	02-U347-M	Warm Springs Creek at Forest Service Boundary	9/19	45 - 02 - 16	111 - 57 - 12
GHCN01	M04GHCNF01	02-U353-M	Greenhorn Creek - North Fork	9/25	45 - 07 - 19	112 - 02 - 21
MORM01	M04MORMC01	02-U352-M	Mormon Creek at road crossing	9/25	45 - 11 - 26	112 - 10 - 22
GARD01	M04GARDC01	02-U350-M	Garden Creek 4 miles upstream from mouth	9/24	45 - 14 - 42	112 - 13 - 00
GARD02	M04GARDC02	02-U351-M	Garden Creek .5 mile above the mouth of Ruby Reservoir	9/24	45 - 13 - 27	112 - 08 - 30
HARR01	M04HARRC01	02-U343-M	Harris Creek above Forest Service Boundary	9/18	45 - 24 - 54	112 - 01 - 09
CAL02	M04CALC02	02-U342-M	California Creek	9/18	45 - 24 - 46	112 - 00 - 05
CAL01	M04CALC01	02-U341-M	California Creek	9/17	45 - 22 - 07	112 - 06 - 39
CURR01	M04CURRC01	02-U339-M	Currant Creek	9/17	45 - 26 - 17	112 - 04 - 01
RAMH01	M04RAMHC01	02-U338-M	Ramshorn Creek	9/17	45 - 26 - 22	112 - 03 - 09
RAMH02	M04RAMHC02	02-U340-M	Ramshorn Creek upstream of hwy 287, near Robbers Roost	9/17	45 - 23 - 37	112 - 08 - 44
MILL01	M04MILLG01	02-U349-M	Mill Gulch	9/24	45 - 25 - 11	111 - 57 - 16
IND01	M04IND01	02-U321-M	Indian Creek 3/4 mi d/s from FS boundary at locked gate	7/12	45 - 29 - 57	112 - 07 - 54
IND02	M04IND02	02-U322-M	Indian Creek u/s of bridge at hwy 287 Sheridan	7/12	45 - 27 - 59	112 - 12 - 12

To assess aquatic invertebrate communities, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used for MVFP sites in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Ruby River watershed. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. Ephemeroptera (mayfly) taxa richness. The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as

silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsygid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery. The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Metrics and scoring criteria for bioassessment of streams of the Montana Valley and Foothill Prairies ecoregion (Bollman 1998a).

Metric	Score			
	3	2	1	0
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 - 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 - 5	5.01 - 10	10.01 - 35	> 35

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.

- Number of “clinger” taxa. So-called “clinger” taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate “clingers” are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected “clinger” taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Habitat Assessment

Figure 1 graphically compares total habitat assessment scores recorded for thirteen sites in this study. Tables 5a, 5b and 5c show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied. Overall habitat conditions generally received positive evaluations; all sites studied were categorized as optimal or sub-optimal.

At the Shovel Creek site (SHOV01), embeddedness of substrate with fine sediment appeared to compromise instream habitat quality. Streambank stability was judged to be moderate, but field notes suggest that some erosion and slumping was observed.

Habitat conditions at the upstream site on Coal Creek (COAL02) were rated optimal. Moderate streambank stability was appraised here. Downstream (site COAL01), high sediment supply was attributed to unstable streambanks; conditions appeared to be natural, however, since it was noted that the stream cut into old landslides.

Benthic gravels were covered with fines at the evaluated site on Hawkeye Creek (HWKE01), and substrate embeddedness by silt particles was perceived to further compromise instream habitat conditions. Moderate streambank stability was noted; outside meanders exhibited erosion and slumping. Overall habitat conditions were rated sub-optimal.

A high supply of fine sediment was reported at the site on the West Fork Ruby River (RURWF01). The score assigned to benthic substrate diversity suggests that the evaluator judged instream habitat to be adversely affected by fines and some embeddedness. Moderate streambank instability was attributed to naturally erosive soils and old landslides.

Optimal habitat conditions were reported at the site on Warm Springs Creek (WRMS01); all instream parameters received high scores. Some disruption of streambank vegetation was noted. On the North Fork of Greenhorn Creek (GHCN01), instream, streambank, and riparian zone parameters were all judged to be in optimal condition.

Naturally high sediment supply from upstream sources appeared to account for the fine sediment deposition in pools at the glide/pool site on Mormon Creek (MORM01). Undercut banks contributed to instream habitat complexity at the site. Minor streambank slumping was judged to be caused by cattle. Despite these observations, overall habitat conditions were rated optimal here.

Habitat quality at both of the evaluated sites on Garden Creek (GARD01 and GARD02) was perceived to be optimal. Minor impacts from cattle grazing were noted; streambank stability was judged to be mildly compromised at the downstream site.

Figure 1. Total habitat assessment scores for 19 sites in the Ruby River Watershed, July and September 2002.

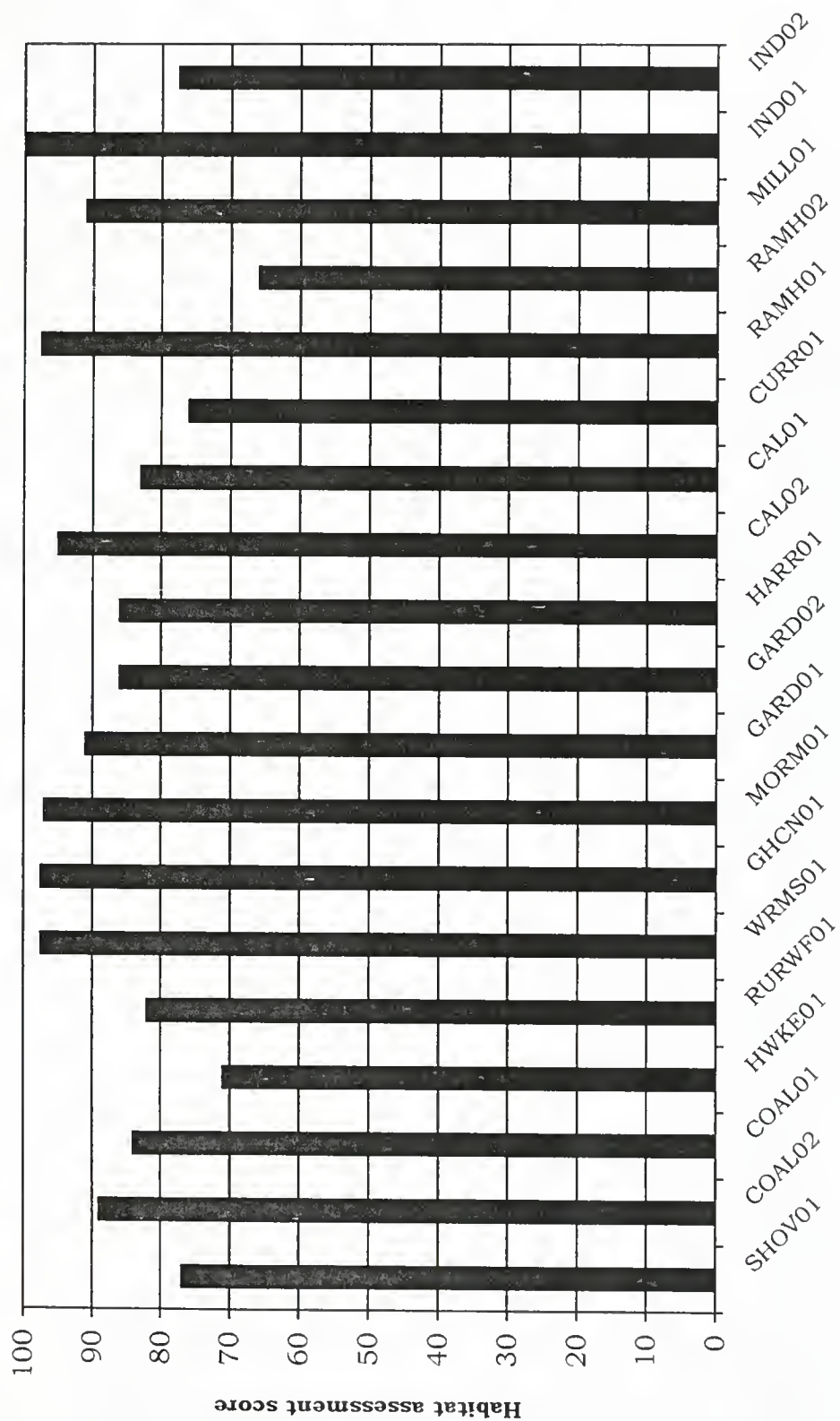


Table 5a. Stream and riparian habitat assessment. These nine sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence and are located above the Ruby Reservoir dam. July and September 2002.

Max. possible score	Parameter	Shovel Creek	Coal Creek 02	Coal Creek 01	Hawk- eye Creek	West Fork Ruby R.	Warm- springs Creek	N.F. Green- horn Creek	Garden Creek 01	Garden Creek 02
10	Riffle development	9	10	10	10	10	10	10	10	9
10	Benthic substrate	8	10	10	8	5	10	10	10	9
20	Embeddedness	6	15	16	6	15	20	20	18	(16)
20	Channel alteration	20	20	20	20	19	20	20	16	18
20	Sediment deposition	12	20	18	6	16	20	20	18	16
20	Channel flow status	20	20	16	20	20	20	20	20	20
20	Bank stability	6 / 6	2 / 2	8 / 8	6 / 6	5 / 5	10 / 10	9 / 9	9 / 9	8 / 8
20	Bank vegetation	8 / 8	8 / 8	9 / 9	6 / 6	9 / 9	8 / 8	9 / 9	9 / 9	8 / 8
20	Vegetated zone	10 / 10	10 / 10	9 / 9	10 / 10	9 / 9	10 / 10	10 / 10	9 / 9	9 / 9
160	Total	123	135	142	114	131	156	156	146	138
Percent of maximum CONDITION*		77 SUB	84 OPT	89 OPT	71 SUB	82 OPT	97.5 OPT	97.5 OPT	91 OPT	86 OPT

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 5b. Stream and riparian habitat assessment. These four sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence and are located below the Ruby Reservoir dam. July and September 2002.

Max. possible score	Parameter	Harris Creek	California Creek 02	Current Creek	Ramshorn Creek 01	Mill Gulch	Indian Creek 02
10	Riffle development	9	10	8	10	10	9
10	Benthic substrate	10	10	9	10	10	9
20	Embeddedness	12	20	11	20	6	19
20	Channel alteration	15	15	16	20	20	16
20	Sediment deposition	15	19	12	20	20	16
20	Channel flow status	20	20	20	20	20	19
20	Bank stability	9 / 9	10 / 10	8 / 8	10 / 10	10 / 10	5 / 5
20	Bank vegetation	9 / 9	9 / 9	8 / 8	9 / 9	10 / 10	6 / 8
20	Vegetated zone	10 / 10	10 / 10	8 / 6	10 / 8	10 / 10	5 / 7
160	Total	137	152	122	156	146	124
Percent of maximum CONDITION*		86 OPT	95 OPT	76 SUB	97.5 OPT	91 OPT	77.5 SUB

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 5c. Stream and riparian habitat assessment. These four sites were assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. Mormon Creek is located above the Ruby Reservoir; the remaining three sites are located below the Ruby Reservoir. July and September 2002.

Max. possible score	Parameter	Mormon Creek	California Creek 01	Ramshorn Creek 02	Indian Creek 01
20	Bottom substrate	18	16	6	20
20	Pool substrate char.	15	18	16	20
20	Pool variability	10	16	6	20
20	Channel alteration	20	12	18	20
20	Sediment deposition	15	19	6	20
20	Channel sinuosity	20	6	15	20
20	Channel flow status	20	19	8	20
20	Bank vegetation	9 / 9	9 / 7	9 / 9	20
20	Bank stability	9 / 9	10 / 9	8 / 8	10 / 10
20	Vegetated zone	10 / 10	5 / 3	5 / 5	10 / 10
180	Total	174	149	119	180
	Percent of maximum CONDITION*	97 OPT	83 OPT	66 SUB	100 OPT

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Platkin et al. 1989.

The site on Harris Creek (HARR01) exhibited good streambank stability, but instream parameters were judged to be mildly affected by sediment deposition and embeddedness. Tailings from old placer mining were noted, but were not thought to greatly affect the channel morphology. Overall habitat conditions were rated optimal.

Signs of old placer mining affected channel morphology at the upstream site on California Creek (CAL02), but habitat quality appeared optimal nevertheless. Instream, streambank, and riparian zone parameters were assigned scores consistent with undisturbed conditions. At the downstream site (CAL01), instream habitat features were appraised as optimal. Channel alteration resulted in a loss of natural sinuosity, but streambanks were judged to be essentially stable. Encroachment of horse and hay pastures on both sides of the stream limited the riparian zone width. Total scores suggested optimal conditions despite these disruptions.

Sub-optimal habitat quality at the site on Currant Creek (CURR01) was mainly attributed to embedded substrates and heavy accumulations of fine sediment. Streambanks were judged moderately stable and vegetative protection was mildly disturbed by grazing. The width of the riparian zone was limited on one side by a road. Overall conditions were rated sub-optimal.

At the upstream site on Ramshorn Creek (RAMH01), instream and streambank features received optimal scores, suggesting minimal disturbance. The riparian zone was reported to be somewhat abbreviated on one side of the stream. Overall habitat conditions were judged to be excellent. Conditions apparently deteriorated downstream, however; several features of site RAMH02 were rated marginal. Major deposition of fine sediments was noted, with pool variability and the quality of benthic habitats negatively affected. Pasture limited the width of the riparian zone on both sides of the stream. Overall habitat conditions scored sub-optimally.

In Mill Gulch (site MILL01), embeddedness of substrate particles by sand was noted, yet overall habitat conditions were rated optimal. All other instream, streambank, and riparian zone features were perceived to be essentially undisturbed.

All habitat parameters evaluated at the upper site on Indian Creek (IND01) received maximal scores, indicating ideal habitat conditions. Downstream, at site IND02, overall habitat quality declined to sub-optimal. This was attributed mostly to moderate instability of streambanks; in addition, the riparian zone width was judged marginal on one side of the stream.

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled in the Ruby River Watershed. Tables 6a and 6b itemize each contributing metric and show individual metric scores for each site. Tables 3a and 3b above show criteria for impairment classifications (Plafkin et al. 1989) and use-support categories recommended by Montana DEQ (Bukantis 1998).

Applying these bioassessment methods to the data gives results that suggest widely varying biologic condition at the sites in this study. Full use support and unimpaired integrity were assessed at 9 sites. Scores indicated partial support of designated uses and slight impairment at 3 sites. Six sites were moderately impaired and partly supported uses, and 1 site was severely impaired and did not support uses. Sites below the Ruby River Reservoir were more likely to attain high bioassessment scores than sites above the reservoir. However, this may have been an artifact of site selection; it appears that more upland sites were sampled below the reservoir than above it. Sites nearer the Ruby River, and thus lower in their respective watersheds, tended to yield lower bioassessment scores whether they were located above or below the reservoir.

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score) for 19 sites in the Ruby River Watershed, August and September 2002. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998) was used to calculate scores.

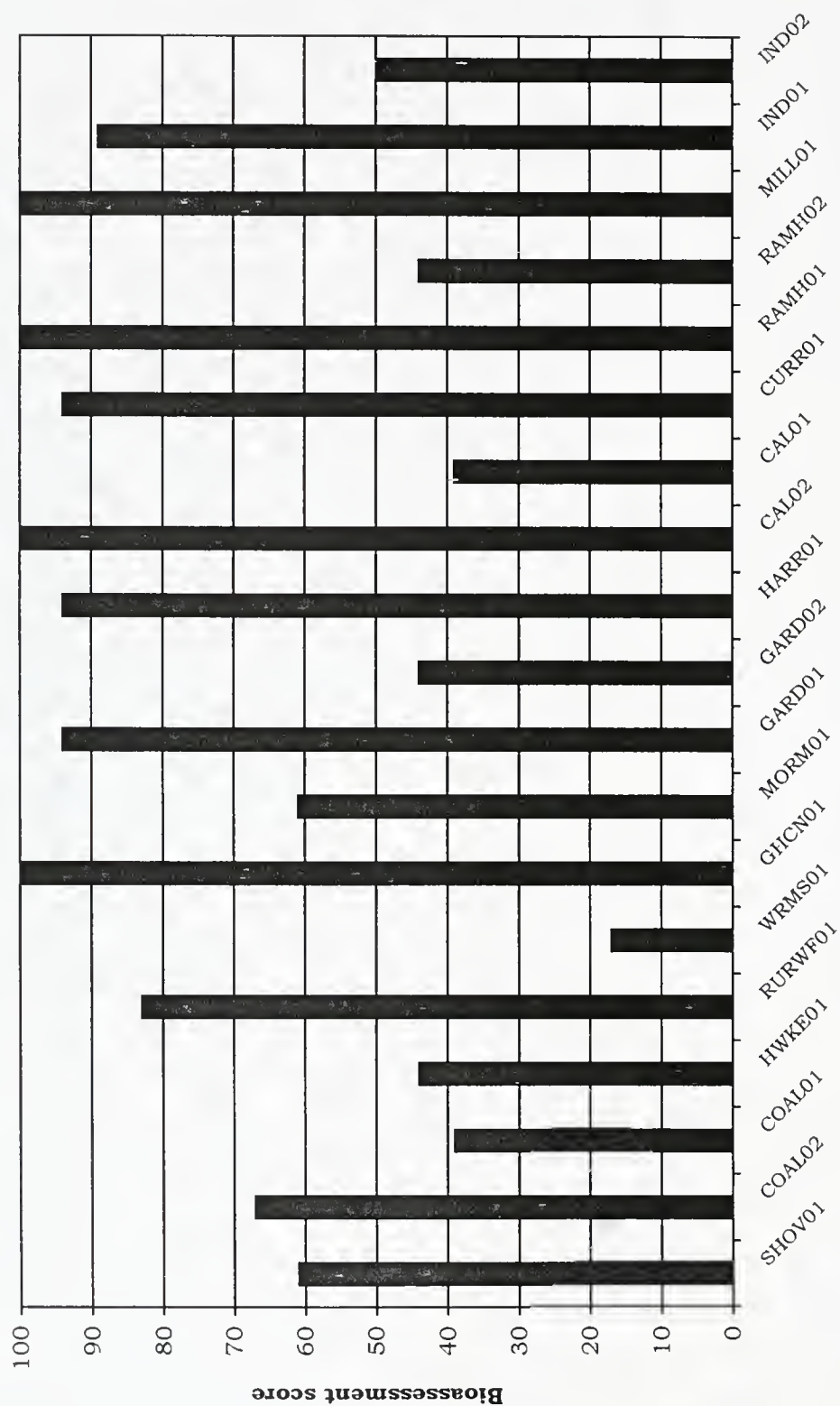


Table 6a. Metric values, scores, and bioassessments for 10 sites in the Ruby River watershed. July and September 2002. Site locations are given in Table 1. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998) was used to calculate scores.

METRICS	SITES										
	SHOV 01	COAL 02	COAL 01	HWKE 01	RURWF 01	WRMS 01	GHCN 01	MORM 01	GARD 01	GARD 02	
METRIC VALUES											
Ephemeroptera richness	5	5	7	3	5	0	9	1	9	1	
Plecoptera richness	4	3	0	1	4	0	6	3	5	4	
Trichoptera richness	6	4	5	4	8	4	9	4	4	4	
Number of sensitive taxa	1	1	0	1	3	0	9	2	5	1	
% filterers	13.6	1.7	15.6	4.1	0.6	10.9	1.5	4.9	0	10.0	
% tolerant taxa	28.4	7.5	45	41.6	5.8	93.4	0.3	7.2	2.5	39.8	
METRIC SCORES											
Ephemeroptera richness	2	2	3	1	2	0	3	0	3	0	
Plecoptera richness	3	2	0	1	3	0	3	2	3	3	
Trichoptera richness	3	2	3	2	3	2	3	2	2	2	
Number of sensitive taxa	1	1	0	1	2	0	3	2	3	1	
% filterers	1	3	1	3	3	1	3	3	3	2	
% tolerant taxa	1	2	0	0	2	0	3	2	3	0	
TOTAL SCORE (max.=18)	11	12	7	8	15	3	18	11	17	8	
PERCENT OF MAX.	61	67	39	44	83	17	100	61	94	44	
Impairment classification*	SLI	SLI	MOD	MOD	NON	SEV	NON	SLI	NON	MOD	
USE SUPPORT +	PART	PART	PART	PART	FULL	NON	FULL	PART	FULL	PART	

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a.

Table 6b. Metric values, scores, and bioassessments for 9 sites in the Ruby River watershed, July and September 2002. Site locations are given in Table 1. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998) was used to calculate scores.

	SITES									
	HARR 01	CAL 02	CAL 01	CURR 01	RAMH 01	RAMH 02	MILL 01	IND 01	IND 02	
	METRIC VALUES									
Ephemeroptera richness	8	9	1	7	9	3	8	11	10	
Plecoptera richness	2	7	2	2	6	2	9	3	3	
Trichoptera richness	6	9	7	7	8	4	7	3	3	
Number of sensitive taxa	7	10	0	7	11	0	13	6	0	
% filterers	1.5	1.3	10.0	5.0	1.0	9.3	0.3	3.5	15.5	
% tolerant taxa	1.5	0.3	76.6	4.0	1.3	30.5	0.6	4.6	15.2	
	METRIC SCORES									
Ephemeroptera richness	3	3	0	3	3	1	3	3	3	
Plecoptera richness	2	3	2	2	3	2	3	2	2	
Trichoptera richness	3	3	3	3	3	2	3	2	2	
Number of sensitive taxa	3	3	0	3	3	0	3	3	0	
% filterers	3	3	2	3	3	2	3	3	1	
% tolerant taxa	3	3	0	3	3	1	3	3	1	
TOTAL SCORE (max.=18)	17	18	7	17	18	8	18	16	9	
PERCENT OF MAX.	94	100	39	94	100	44	100	89	50	
Impairment classification*	NON	NON	MOD	NON	NON	MOD	NON	NON	MOD	
USE SUPPORT †	FULL	FULL	PART	FULL	FULL	PART	FULL	FULL	PART	

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

The biotic index value (3.96) calculated for the sampled assemblage from the site on Shovel Creek (SHOV01) was somewhat higher than expected for a foothill stream, and the number of mayfly taxa taken at the site was somewhat lower than expected. These findings suggest that water quality may have been mildly degraded here, possibly by nutrient enrichment or slightly elevated water temperatures; either of these impacts or a combination of the two could explain both the elevated biotic index value and the paucity of mayfly taxa here. Among the midges, hemoglobin bearing taxa are abundant; these include *Microtendipes* sp., *Radotanyptus* sp., and *Stictochironomus* sp. The relatively high proportion of these animals (14% of the sampled animals) suggests that substrates may have been hypoxic, which can result from the effects of nutrient enrichment and/or warm water temperatures.

Habitat indicators suggested undisrupted habitat on both large and small scales. The number of caddisfly taxa (6) was within expectations for a foothill stream and "clinger" taxa (16) were abundant; these findings imply that fine sediment deposition did not appreciably undermine biotic health at the site. Larger scale habitat features, such as channel morphology, riparian zone function, and streambank integrity appear to have been essentially intact, since the number of stonefly taxa (4) collected at the site was ample. Seven long-lived taxa were present, indicating that surface flow persisted year-round, and no catastrophic events aborted life cycles in this reach. Functionally, the invertebrate assemblage appeared to be skewed toward gatherers. Scrapers seemed to be underrepresented, suggesting that turbidity or riparian shading may have inhibited the growth of algal films.

At the upper site on Coal Creek (COAL02), the biotic index value (4.47) was elevated relative to expectations. Mayfly taxa richness was mildly depressed; the site supported only 5 taxa. Twenty-three percent of sampled organisms were immature tubificid worms. These findings suggest that water quality degradation may have affected the taxonomic composition of the invertebrate assemblage at this site. Mild nutrient enrichment seems to be a possible cause of the degradation.

Low caddisfly taxa richness (4 taxa) suggests that fine sediment deposition may have been a further impairment. Although 10 "clinger" taxa were represented, they represented only 9% of the total assemblage; their low numbers support the hypothesis that clean benthic substrate habitats were less available than expected at this site. Four stoneflies in 3 taxa were collected, suggesting that reach-scale habitat features such as streambank integrity, natural channel morphology, or riparian zone function may have been disturbed. Among the functional components, shredders were abundant but not diverse; only 3 shredder taxa were collected, and among these the caddisfly *Lepidostoma* sp. accounted for 41% of sampled organisms. Only a single individual of each of the other 2 shredder taxa was present. The abundance of *Lepidostoma* sp. resulted in a rather monotonous taxonomic and functional composition, and suggests that habitat and/or water quality disturbances limit the biotic assemblage at this site.

Downstream, abundant *Lepidostoma* sp. persisted at site COAL01, but here they accounted for only 22% of sampled organisms. The biotic index value (2.75) was much lower at this site, and 7 mayfly taxa were collected. Water quality appears to have been better at this site than at the upstream location. However, not a single sensitive taxon or cold-stenotherm was present in the sample, and the caddisfly *Helicopsyche borealis*

was the most commonly encountered creature. This animal prefers warmer water temperatures; its abundance suggests that thermal conditions at this site may have deviated somewhat from expectations.

Five caddisfly taxa and 12 "clinger" taxa suggest that fine sediment deposition did not appreciably limit instream habitats. However, reach-scale habitat features may have been compromised; not a single stonefly was collected here. The presence of 5 semivoltine taxa was evidence that dewatering or other life-interrupting catastrophes did not recently disturb conditions at this site. All expected functional components of a foothill stream assemblage were present in appropriate proportions.

Low mayfly taxa richness and a relatively high biotic index value (4.61) suggest that water quality was impaired at the site on Hawkeye Creek (HWKE01). Diptera dominated the faunal elements; 67% of sampled organisms were flies (including midges), and tolerant taxa comprised 42% of the assemblage. The psychodid fly *Pericoma* sp. was the most prolific animal; this organism is frequently abundant in calcareous waters. It is possible that high specific conductance was a characteristic of this reach. The midge *Stichtochironomus* sp. was abundant at the site; this animal carries hemoglobin in its circulating fluids, enabling it to exploit hypoxic habitats. Low oxygen conditions in the substrate appear to have been likely.

A single stonefly was collected here; reach-scale habitat features may have suffered disturbance. Disturbances could include channel alteration, riparian zone damage, or loss of streambank integrity. Thirteen "clinger" taxa were present, but only 4 caddisfly taxa appeared in the sample. Nevertheless, it appears that clean, hard substrates, unimpaired by fine sediment deposition were available for colonization at this site. Three long-lived taxa were collected, but none were abundant; 2 of these taxa were represented by single individuals. It's possible that this could be the result of dewatering or other life-interrupting events such as periodic thermal impacts or toxic influences. The functional composition of the assemblage collected at this site was skewed toward gatherers. Piercers, especially a large contingent of the microcaddisfly *Hydroptila* sp. were dominant components. This caddisfly is often associated with filamentous algae.

Good water quality appears to have characterized the sampled site on the West Fork Ruby River (RURWF01). Mayfly taxa richness (5) was slightly lower than anticipated, but the biotic index value (3.16) was within expectations for a foothill stream. No fewer than 3 cold stenothermic taxa were supported at the site, including the sensitive mayfly *Drunella doddsi* and the midge *Cricotopus nostococladius*. Cold, clean water appears to be indicated by these findings.

Caddisfly taxa richness (8) was high, suggesting that fine sediment deposition did not obliterate hard substrate habitats; the number of "clinger" taxa (17) strengthens this hypothesis. Four stonefly taxa were present in the sample; this finding corresponds to expectations for a foothill watershed in which riparian zone function, stream channel morphology, and streambank integrity are all essentially intact. Among the five long-lived taxa taken in the collection from this site was the perlid stonefly *Hesperoperla pacifica* as well as three genera of elmids. The functional composition of the invertebrate assemblage was consistent with that of a foothill stream. Abundant shredders suggest ample inputs of organic debris from the riparian zone and hydrologic conditions that promote retention of such material.

The sampled site on Warm Springs Creek (WRMS01) yielded a unique assemblage compared to the others in this study. While scores suggest severe biological impairment, it's possible that conditions on Warm Springs Creek were unusual for the region. Water quality indicators gave conflicting results: not a single mayfly was present in the sample, yet the biotic index value (3.66) was only moderately elevated above expectations. High specific conductance is one possible interpretation of the dearth of mayflies. Metals contamination may also be implicated, since the lack of mayflies was accompanied by a lack of tanytarsine midges. However, relatively warm water temperatures are strongly suggested by the taxonomic composition of the invertebrate

assemblage, and offer another possible explanation for the observed idiosyncrasies of the biota. The caddisflies *Helicopsyche borealis* and *Cheumatopsyche* sp., and the beetle *Microcylloepus* sp. were the dominant taxa collected here, making up 88% of sampled organisms; these animals prefer warmer thermal regimes. Significant organic enrichment appears unlikely, since no hemoglobin-bearing midges or worms were collected. The name of the waterway suggests the influence of thermal springs; while this is not obvious from the invertebrate data, it's certainly not out of the question, either.

No stoneflies were collected; this is likely a further indication of unusual water quality, but could also indicate disruption of reach-scale habitat features such as streambank integrity or channel morphology. Only 8 "clinger" taxa were collected, but these taxa were dominant, comprising 91% of sampled animals and suggesting that fine sediment deposition did not appreciably limit the availability of hard benthic surfaces for colonization. Several semivoltine taxa were present, indicating the probability that dewatering or other catastrophes were not among recent events in this reach of Warm Springs Creek. Functional components of the assemblage were drastically skewed toward scrapers, which may be an artifact of unique conditions; it strongly suggests that the sampled reach was not excessively shaded.

On the North Fork of Greenhorn Creek (site GHEN01), habitat and water quality indicators all yielded maximum scores, suggesting excellent conditions. The biotic index value (1.56) was the lowest calculated for sites in this study. The mayfly fauna was rich and diverse; at least 9 taxa were present at the site. Among them were the sensitive cold-stenotherms *Caudatella hystrix* and *Drunella doddsi*. Forty-six percent of the sampled assemblage was comprised of cold-stenotherms. Clean, cold water appears to be indicated. Only a few midges were collected, suggesting that an area of rapid flow was sampled.

Nine caddisfly taxa and 22 "clinger" taxa strongly suggest that hard benthic surfaces were uncompromised by fine sediment deposition. Reach-scale habitat features were likely intact as well; stonefly taxa richness (6) was exceptional here. Among the stoneflies present were the sensitive perlid *Doroneuria* sp. and the leuctrid *Despaxia augusta*. Abundant semivoltine taxa indicate that no recent catastrophes interrupted long life cycles. Surface flow is apparently a year-round phenomenon. The functional composition of the assemblage is consistent with that of a montane or foothill stream in good condition.

The biotic index value (3.62) calculated for the invertebrate assemblage collected at Mormon Creek (MORM01) was somewhat elevated relative to expectations for a foothill stream. In addition, only 1 mayfly taxa was present in the sample. The dearth of mayfly taxa is ordinarily a fairly strong signal that water quality impairment is present at a site. However, the biotic index value does not seem to be sending so strong a signal. In this case, the biotic index calculation appears to be skewed on account of the presence of 164 specimens of the elmids *Heterlimnius* sp., some 54% of the sampled assemblage. These gregarious beetles can overwhelm samples when the sampler serendipitously encounters large numbers of them in a relatively small area of the sampled reach. Samples overwhelmed by elmid beetles are difficult to interpret, since taxa richness is likely artificially limited, and metrics calculated on the basis of relative abundances probably do not reflect the actual composition of the assemblage present at the sampling location. Interestingly, if *Heterlimnius* sp. were excluded from the sample collected at Mormon Creek, the biotic index value which would result for the remaining members of the invertebrate assemblage would be 4.35, considerably higher, and probably more consistent with the observed low Ephemeroptera taxa richness. Though subtle on account of the dominance of a single taxon, there is other evidence of water quality impairment in the taxonomic composition of the sample collected at this site; tolerant, hemoglobin-bearing midges were present, including *Polypedilum* sp. and *Radotanytus* sp. Immature tubificid worms, and lymnaeid snails also appeared to be

supported at the site. Impairment to water quality in this reach may have been due to nutrient enrichment.

Stoneflies were poorly represented in the fauna at this site; only 3 taxa were present, and none was abundant. Twelve "clinger" taxa were collected, but only 4 caddisfly taxa appeared to be present. Still, it seems likely that fine sediment deposition was not an extremely influential impact on benthic habitat availability; this seems unlikely given the large numbers of *Heterlimnius* sp. supported at the site. Four long-lived taxa were collected, implying that dewatering or other life cycle interruptions were not recent events in this reach. Functionally, the assemblage was skewed toward gatherers, consistent with the overwhelming number of elmids. Other functional components expected in a foothill stream were present, however, and the actual proportional representation of these groups at the site may not have been accurately reflected in the sample.

Four miles above its mouth, Garden Creek (GARD01) supported a diverse, rich, and sensitive invertebrate fauna suggestive of good water quality and undisturbed habitat. Similar to the sample collected at Mormon Creek, the sample collected here also exhibited an overwhelming preponderance of *Heterlimnius* sp., probably representing a random encounter by field personnel with a large convergence of the animals. However, in contrast to the assemblage at the Mormon Creek site, this community would have a biotic index value of 2.17 if *Heterlimnius* sp. were excluded from the calculation, suggesting that the other animals comprising the upper Garden Creek fauna were, as a group, much more sensitive than the fauna present in Mormon Creek. Even including the dominant taxon, the biotic index value (2.58) was low, and suggestive of good water quality. No fewer than 9 mayfly taxa were supported at the site, and among these were the sensitive cold-stenotherms *Drunella spinifera* and *Baetis bicaudatus*. It appears that cold, clean water characterized the site.

The 5 stonefly taxa collected here suggest that reach-scale habitat features may have been undisturbed. Although the number of caddisfly taxa was somewhat lower than expected for a foothill stream, there were at least 15 "clinger" taxa at the site. These findings suggest that fine sediment deposition probably did not appreciably affect the benthic assemblage. Four semivoltine taxa were among those taken in the sample; catastrophes such as loss of surface flow probably did not occur here in the recent past. The functional composition of the sampled assemblage was skewed toward gatherers, reflecting the habit of the dominant taxon. However, all other expected components of a well-functioning foothill community were amply represented in the sample.

Downstream, both water quality and instream habitat features of Garden Creek (site GARD02) appear to be reflected in the benthic assemblage. Since no single taxon overwhelmed the sample, many indicators are more easily interpreted at this site. The biotic index value (3.90) was elevated compared to expectations for a foothill stream, and only 1 mayfly taxon appeared in the sample. These findings suggest that water quality may have limited biotic health in this reach. Nutrient enrichment and/or warm water temperatures could account for the pattern of low mayfly taxa richness and elevated biotic index. Physid snails were abundant at the site, supporting the hypothesis of impaired water quality.

The number of caddisfly taxa (4) was less than expected. Nevertheless, fine sediment deposition does not appear to have been a significant limitation to benthic colonization since the 11 "clinger" taxa collected here represented 82% of sampled organisms. Elmid beetles were abundant, and they comprised 3 of the 5 long-lived taxa taken in the sample. Long-lives were apparently uninterrupted by catastrophic events. The functional composition of the assemblage appeared to be appropriate for a foothill stream.

The sampled site on Harris Creek, above the Forest Service boundary (HARR01), supported at least 7 cold-stenotherm taxa; these included the heptageniid mayfly *Cinygma* sp. and the stonefly *Doroneuria* sp. However, the sample collected at the site was overwhelmed by the elmid *Heterlimnius* sp., making the interpretation of metrics

and other indicators problematic. In this case, the beetle made up 74% of the sampled assemblage. It would seem, however, that cold, clean water probably characterized the milieu for the benthic fauna at this site, since the biotic index value, including the dominant taxon, was 2.89; not including *Heterlimnius* sp., the value was 2.25. This hypothesis is supported by the large mayfly taxa richness (8 taxa) at the site.

Seventeen "clinger" taxa and 6 caddisfly taxa were collected; benthic substrates were probably clean and unimpaired by fine sediment deposition. The number of stonefly taxa in the site, however, was depressed, suggesting the possibility that reach-scale habitat features such as riparian zone function, streambank integrity, or channel morphology may have suffered from some disturbance. Six semivoltine taxa were taken in the sample, implying the presence of year-round surface flow and the absence of events which would abort long life cycles. The functional composition of the assemblage demonstrated the same skew toward gatherers notable in the other samples dominated by *Heterlimnius* sp. Other expected functional components were present, but none of these were abundant.

The upland site on California Creek (CAL02) supported a rich, sensitive assemblage characteristic of near-pristine streams in the foothills. The fauna included 9 mayfly taxa, among which were the sensitive taxa *Drunella doddsi* and *Baetis bicaudatus*. The biotic index value (2.29) was well within expectations. The benthic community included 10 cold-stenotherm taxa. Cold, clean water is suggested.

Both reach-scale and instream habitat indicators gave results consistent with unimpaired conditions. Nineteen "clinger" taxa and 9 caddisfly taxa suggest that benthic habitats were free of deposited fine sediment. Seven stonefly taxa imply undisturbed reach-scale features such as streambanks, riparian function, and channel morphology. Forty percent of collected animals were long-lived types, indicating that surface flow was not interrupted by dewatering, and toxic inputs or other disasters did not abort life cycles here. Functionally, all expected components were present, although gatherers dominated the mix.

Water quality appears to have deteriorated between the upstream site on California Creek and the downstream site (CAL01). However, the sample was swamped with abundant elmids in the genus *Optioservus* sp. (65% of sampled organisms). Like its relative *Heterlimnius* sp., this beetle exhibits gregarious habits, and large numbers of them can overwhelm samples serendipitously, rendering the data difficult to interpret. The biotic index value (4.79) is elevated relative to expectations for a foothill stream. Even when calculated for the remaining animals when *Optioservus* sp. is removed from the mix, the value (4.41) is still high. Only 1 mayfly taxon was present in the sample; this was the tolerant and ubiquitous *Baetis tricaudatus*. The presence of the snails *Physa* sp. and *Gyraulus* sp. suggest that nutrient enrichment and/or warm water temperatures may impact the benthic assemblage at this site. No cold-stenotherms were collected.

Reach-scale habitat features may have suffered some disturbance; this may be reflected in the small number of stonefly taxa (2) taken in the sample. Only 6 individual stoneflies were present. Fine sediment deposition does not seem to have obliterated hard benthic substrates, since the caddisfly fauna was quite rich (7 taxa) and at least 12 "clinger" taxa were supported at the site. Year-round flow appears to have been the rule recently here, since 4 long-lived taxa were present, and 1 (*Optioservus* sp.) was particularly abundant. The functional mix was dominated by scrapers; *Optioservus* sp. is thought to function as a scraper. Other expected components were present, but none were abundant.

The low biotic index value (2.90) and rich mayfly fauna (7 taxa) at the site on Currant Creek (CURR01) suggest that water quality was essentially unimpaired by nutrients or thermal impacts. The site supported at least 7 cold-stenotherm taxa, including the predatory caddisfly *Parapsyche elsis*, and the sensitive mayfly *Drunella doddsi*. Cold, clean water is suggested by these findings.

Fifteen "clinger" taxa and 7 caddisfly taxa were present at the site, suggesting clean substrates unpolluted by fine sediment deposition. Reach-scale habitat features may have been disturbed, however, since the stonefly taxa richness was less than expected. Only 13 individual stoneflies in 2 taxa were collected at the site. Stonefly taxa richness may be associated with impairment to streambank stability, riparian zone function, or natural channel morphology. Six long-lived taxa persisted at the site, suggesting that year-round surface flow characterized this reach of Currant Creek. All expected functional components of a healthy montane or foothill system were present.

Excellent water quality and cold temperatures are indicated at the upstream site on Ramshorn Creek (RAMH01). The biotic index value (2.30) was low, the mayfly fauna was rich (9 taxa), and 11 taxa were cold-stenotherms. Among the taxa collected at the site were the sensitive stoneflies *Megarcys* sp. and *Doroneuria* sp., and the sensitive dipteran *Glutops* sp. No impairment by nutrient enrichment or thermal impact is likely, given the taxonomic composition of the benthic assemblage.

Habitat indicators yielded maximum scores for this site. Eighteen "clinger" taxa appeared in the sample, and no fewer than 8 caddisfly taxa were supported at the site. Fine sediment deposition apparently did not diminish biotic potential here. Reach-scale habitat features, such as streambank condition, riparian zone function, and channel morphology were probably in very good condition, since stonefly taxa richness was high; 6 taxa were collected. Long-lived animals were abundant, and the semivoltine fauna was rich (5 taxa). This implies the absence of catastrophic events that would interrupt life cycles, such as dewatering or toxic inputs. The functional mix included all expected components, but shredders appeared to be underrepresented. This suggests that riparian inputs of organic debris were limited, or that hydrologic conditions in this reach were not conducive to the retention of such material.

At the lower site on Ramshorn Creek (RAMH02), mild degradation of water quality appears to be indicated by the somewhat elevated biotic index value (3.83). The mayfly fauna lacked richness; a single family, Baetidae, was represented by 3 genera. No sensitive insects were taken in the collection, and no cold-stenotherms were present either. Warmer than expected water temperatures appear to be indicated by these findings. Certain taxa collected here prefer warmer temperatures; among them are the soldier fly *Caloparyphus* sp., and the snails *Fossaria* sp., *Physa* sp., and *Gyraulus* sp.

Only 5 "clinger" taxa were taken in the sample, and the caddisfly fauna was depauperate (18 individuals in 4 taxa). This could be interpreted as evidence that fine sediment deposition compromised substrates, and prevented colonization by organisms which prefer clean, hard benthic habitats. Reach-scale habitat features may also have been disturbed, since the stonefly taxa richness (2) was less than expected. Four long-lived taxa were supported here, but 2 of them, the adult dytiscid beetles *Stichtotarsus* sp. and *Oreodytes* sp., are vigorous colonizers, and may have been recent additions to the fauna at the site. Thus, it's possible that dewatering or other catastrophes may have recently aborted life cycles at this site. Functionally, scrapers seem to be underrepresented here, given the relative location of the site.

The low biotic index value (2.32) calculated for the sampled assemblage from Mill Gulch (MILL01) suggests that water quality was essentially unimpaired at this site. The rich mayfly fauna (8 taxa) included some sensitive organisms, such as *Drunella doddsi* and *Cinygma* sp., and supported a hypothesis of water quality unimpaired by nutrient enrichment or toxic agents. No fewer than 10 cold-stenotherms were present at the site, implying that water temperatures were low, consistent with expectations for a montane or foothill stream.

The rich stonefly assemblage (9 taxa) included the chloroperlid *Paraperla* sp.; the diversity of this group suggests that reach-scale habitat features were intact. The presence of *Paraperla* sp. implies that substrates were not embedded, making hyporheic habitats accessible. A wide variety of "clinger" taxa (13) were supported at the site and 7 caddisfly taxa were collected. Fine sediment deposition apparently did not compromise benthic substrates. The long-lived stonefly *Yoraperla* sp. was abundant here, suggesting

that flow had not recently been interrupted by dewatering, and no catastrophic toxic inputs aborted life cycles here. All expected functional components of an intact montane assemblage were amply represented. Notable is the abundance of shredders, implying good riparian sources of organic debris and hydrologic conditions conducive to its retention.

At the upper Indian Creek site (IND01), sampling yielded only 172 total organisms. Assessment and interpretations based on a sample with so few animals cannot be reliable. However, a few observations about the small assemblage can be made. A very low biotic index value (1.84) was calculated for the community, and a very rich mayfly fauna was present; 11 taxa were represented. Among these were some sensitive species, such as *Drunella doddsi*, and *Baetis bicaudatus*. Six cold-stenotherm taxa were taken in the sample. Cold, clean water is indicated.

Only 3 stonefly taxa were collected; this suggests the possibility that there was some disruption of reach-scale habitat features. The disruption may have affected riparian zone function, streambank stability, or channel morphology. Eighteen "clinger" taxa were among the assemblage, but only 3 caddisfly taxa were collected. Since "clingers" comprised 77% of sampled animals, it seems likely that fine sediment deposition was not a strong factor influencing composition of the benthic community. Four semivoltine taxa were present; dewatering seems not to have been a recent impact in this reach. Functionally, all expected components were present, but the proportion of gatherers was larger than expected; this appeared to be a consequence of the well-developed and prolific mayfly fauna. Shredders were relatively underrepresented at this site; perhaps riparian inputs of organic debris were limited, or hydrologic conditions may not have favored retention of this material.

Not unexpectedly, the downstream site on Indian Creek (IND02) yielded a higher biotic index value (3.85), suggesting some mild impairment of water quality here. Relatively high mayfly taxa richness (10 taxa) appears to conflict with the biotic index calculation, but immature tubificid worms and the snail *Fossaria* sp. were rather abundant. This suggests that some nutrient enrichment may have affected taxonomic composition of the benthic assemblage at this site. While not dominant, filter-feeders were abundant here; most of them were the blackfly *Simulium* sp. This finding gives strength to a hypothesis of some enrichment at this site.

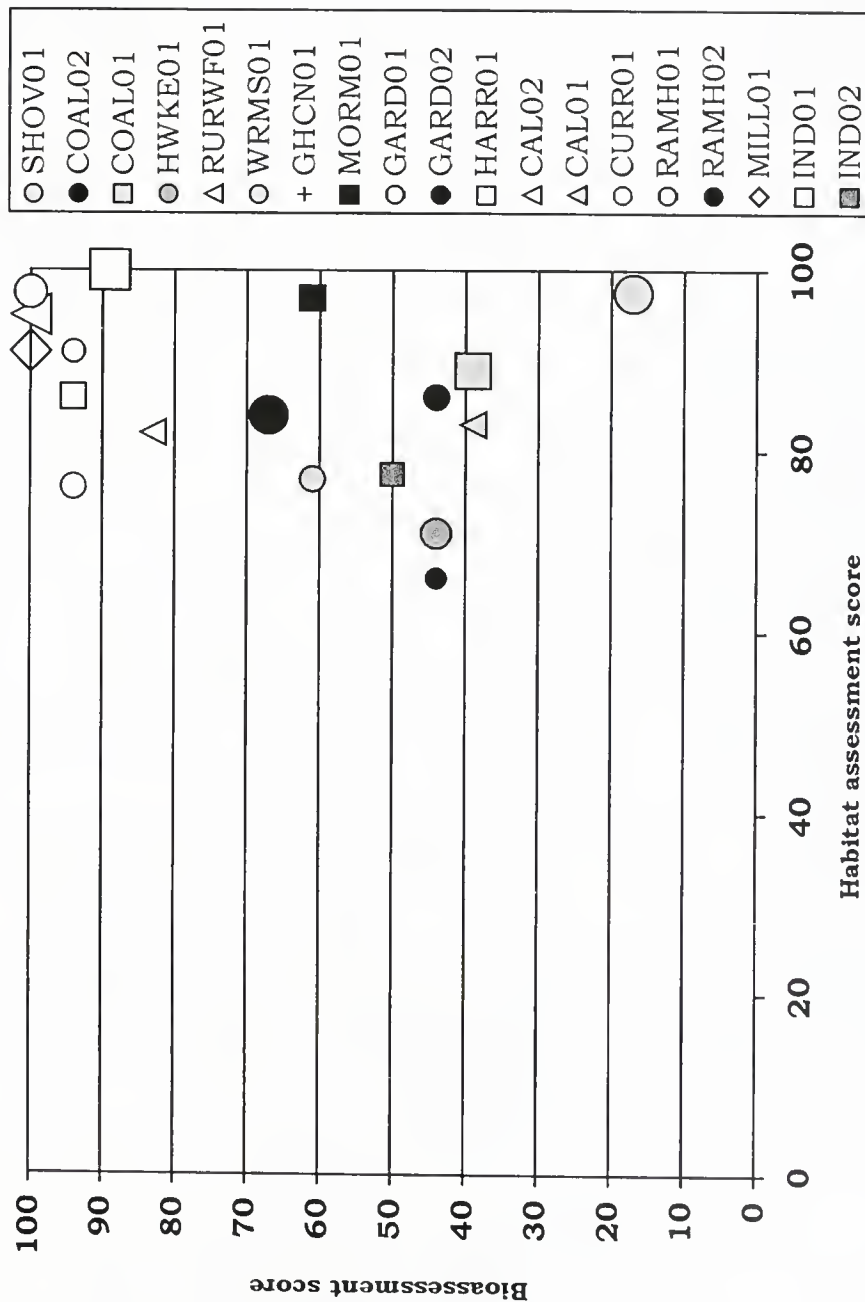
Habitat indicators suggested some impairment of both reach-scale and instream habitat. Only 3 stoneflies were taken in the sample, suggesting some disturbance to streambanks, riparian zone integrity, or channel components. The effects of possible fine sediment deposition can be seen in the low caddisfly taxa richness (3 taxa) and abundance (15 animals). Ten "clinger" taxa were collected, but less than half of collected organisms were "clingers". The functional composition of the assemblage was within expectations for a downstream site. Predators were uncommon, however, which may have been a consequence of habitat simplification due to sediment deposition. Although 3 long-lived taxa were present, they were represented by only 4 individual animals. The possibility that dewatering or other life-interrupting disasters occurred recently cannot be excluded.

CONCLUSIONS

- Water quality degradation is suggested by metric performance and taxonomic data for the sample collected at Shovel Creek (SHOV01), lower Garden Creek (GARD02). Impairment could be accounted for by nutrient enrichment and/or warmer than expected water temperatures.
- Water quality impairment, fine sediment deposition and reach-scale habitat disturbance may affect the invertebrate assemblage integrity at the upper site on Coal Creek (COAL02), and at the lower site on Ramshorn Creek (RAMH02)

- Warm water temperatures are suggested by the taxonomic composition of the sample collected at the lower site on Coal Creek (COAL01). Reach scale habitat features may have also suffered disturbance.
- Water quality impacts appear to affect integrity of the biotic assemblage at the site on Hawkeye Creek (HWKE01). Reach scale habitat features may have also suffered disturbance here. Recent dewatering or other catastrophes cannot be ruled out.
- Good water and habitat quality support sensitive, functional benthic invertebrate assemblages in the sampled reaches of West Fork Ruby River (RURWF01), North Fork Greenhorn Creek (GHCN01), upper Garden Creek (GARD01), upper California Creek (CAL02), upper Ramshorn Creek (RAMH01), Mill Gulch (MILL01)
- A unique assemblage collected from Warm Springs Creek (WRMS01) suggests unique water quality conditions at this site. Thermal influence or metals contamination are among the possible explanations for the findings associated with the sample collected here.
- Overwhelming numbers of elmids were collected at the site on Mormon Creek (MORM01), complicating interpretation of the data. Water quality impairment may have been indicated by other taxonomic evidence, and some reach-scale disturbances may also have been suggested.
- Overwhelming numbers of elmids were collected at the site on Harris Creek (HARR01), complicating interpretation of the data. Nevertheless, water quality did not seem to be impaired. Reach-scale habitat features may have suffered some disturbance.
- Overwhelming numbers of elmids were collected at the lower site on California Creek (CAL01), complicating interpretation of the data. Water quality impairment may have been indicated by other taxonomic evidence, and some reach-scale disturbances may also have been suggested.
- Good water quality appears to have characterized the sampled reaches of Currant Creek (CURR01) and upper Indian Creek (IND01), but reach-scale habitat features may have been disturbed at these sites.
- At the lower site on Ramshorn Creek (RAMH02), water quality impairment, fine sediment deposition and reach-scale habitat disturbance may affect invertebrate assemblage integrity. Dewatering or other disasters cannot be ruled out.
- Mild nutrient enrichment may affect the benthic assemblage at the lower Indian Creek site (IND02). Some impairment due to sediment deposition as well as reach-scale habitat disturbance also seemed to be indicated.
- Figure 3 illustrates the relationship between habitat assessment scores and bioassessment scores for the 19 sites in this study. In the graph, filled symbols fall in the area of the graph where habitat scores are considerably higher than bioassessment scores, suggesting that water quality impairment is the major limitation to benthic assemblage composition.

Figure 3. Total bioassessment scores plotted against habitat assessment scores for sites in the Ruby River watershed, July and September 2002. Unfilled symbols represent sites at which habitat and bioassessment scores suggest good habitat and water quality. Filled symbols represent sites at which habitat scores suggest good habitat conditions, while bioassessment scores suggest biologic impairment, implying that water quality may be degraded (Barbour and Stribling 1991).



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